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ROOT HABITS OF LONGLEAF PINE SEEDLINGS

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Longleaf pine (*Pinus palustris* Miller) in its seedling stage is markedly different in its development from other species of pine indigenous to the Southern States. Most pines commence to grow in height soon after germination, but the stems of longleaf seedlings remain stunted for several years. In this condition they are hardly distinguishable from the grass that surrounds them. The duration of this so-called "grass-stage" depends on the condition of the site, the prevalence of the brown spot needle disease (*Septoria acicola* Thum), the character and density of the ground cover, including the seedling stand. Longleaf pine seedlings under favorable conditions sometimes begin height growth four years after germination, while under adverse conditions they may not begin height growth for thirteen years or more. What happens to the root system during this period of slow growth of the stem? To answer this question a study of the roots of longleaf pine seedlings was started near Bogalusa, La. during 1933-34. An area was selected on which the site conditions were uniform and on which all the seedlings were of the same age. On this area two milacre quadrats were laid out. On one quadrat there were 24 longleaf pine seedlings and on the other 185 seedlings of the same age. On both milacres the seedlings were in their thirteenth growing season. The vegetation consisted of native piney woods grasses (*Andropogon scoparius* and *Andropogon Elliottii*) and a few legumes, the principal one being Devil's shoe string (*Cracca augustifolia*). The soil was Ruston fine sandy loam and was well drained. The degree of the intensity of the brown-spot needle disease was similar on both quadrats and the seedlings showed indications of heavy periodic defoliation. The only major difference between the two milacre quadrats was in the density of the stocking to seedlings.

Method of excavation of the roots

The milacre quadrats were marked off with white string and sub-divided into small squares (7.92 x 7.92 inches). On each of these squares the pine seedlings and the vegetation were mapped. Along the full length of one side of each quadrat a trench 4 feet deep and 3 feet wide was dug, and the roots of the pine seedlings were carefully excavated with an ice pick and sketched to scale. After a seedling had been completely excavated, it was removed to the laboratory where it was mounted on a large paper marked off in inch squares. The measurements of the roots of the seedlings were then checked with those on the sketch made in the field and the seedling photographed in the mounted position.

Fig. 1. - Trench along side of quadrat which served as the starting point for the excavation of the roots of the pines.

Fig. 2. - Trench showing places from which seedlings have been excavated. Above the pad of paper can be seen the pine seedlings in the milacre quadrat. These 13 years old longleaf pine seedlings are indistinguishable from the surrounding grasses.

Results and conclusions

The measurements of the excavated seedling roots in each plot are shown in Tables 1 and 2 respectively. The measurements of the individual seedlings as well as the average for each height class are given. The length of the stems of the excavated seedlings in the milacre with the heavy density varied from 0.6 to 3.1 inches, averaging 1.5 inches, while the length of the tap root varied from 15.6 to 57.6 inches, averaging 27.6 inches, or about 18 times greater than the length of the stem. Seedlings averaging 1.5 inches in height had an average total length of lateral roots of 65 inches and an average number of 26 lateral roots. The length of the stems in the quadrat with the smaller density varied from 1.0 inch to 4.0 inches, averaging 2 inches for the twenty-one seedlings excavated, while the length of the tap root varied from 16 to 66 inches, averaging 34 inches for the number of seedlings excavated, or 17 times greater than the length of the stems. The average seedling 2.0 inches in height had a total length of lateral roots amounting to 88 inches, with an average number of 31 lateral roots.

When the 19 seedlings excavated in the heavy density plot were arranged into height classes, ten seedlings fell into the 1 inch class, seven into the 2 inch class, and two seedlings fell into the 3 inch class. The average length of the tap root for the root for the 1 inch class was 25 times the length of the stem, for the 2 inch class 15 times, and for the 3 inch class 9 times the length of the stem, indicating that the ratio of the growth of the tap root to that of the stem decreases as the growth in height of the stem increases. The number of lateral roots became greater with increased height of stem. The average number of lateral roots for the 1 inch class seedlings was 22, for the 2 inch class 28, and for the 3 inch class 37. The total length of the lateral roots likewise showed a definite correlation with the size of the stem. The lateral roots of the seedlings in the 1 inch height class showed an average total length of 47 inches, those of the 2 inch class 63 inches and the average total length of the seedlings in the 3 inch class amounted to 160 inches.

When the 21 seedlings from the low density quadrat were arranged into height classes, five seedlings fell into the 1.0 inch class, thirteen into the 2 inch class, one into the 3 inch and two into the four inch class. The average length of the tap roots for the 1 inch class was 29 times the length of the stem, for the 2 inch class 17 times, and for the 4 inch class 15 times the length of the stem. Here also the number of lateral roots was proportional to the size of the seedlings. The average number of lateral roots for the 1 inch class was 22, for the 2 inch class 30, for the 4 inch class 45. Seedlings in the 1 inch class possessed an average total length of the lateral roots of 46 inches, those in the 2 inch class 96 inches, and those of the 4 inch class attained an average length of 112 inches.

It is significant that in the dense quadrat most of the seedlings fell into the 1 inch class, whereas in the other most of the seedlings fell into the 2 inch class, indicating that the density of the stocking had a retarding effect not only on the growth of the stems but also on the development of the root system.

Table 1. - Measurements of roots of longleaf pine seedlings

Density: 185 seedlings per milacre. Age: 13 years

Ht. of seedlings	Diameter of seedlings	Length of tap root	No. lateral roots	Total length lateral roots	Depth of occurence of most lateral roots
Inches		Feet		Feet	
0.6	.3	1.3	9	.8	.7
1.0	.5	2.8	16	3.8	.7
1.0	.5	3.2	22	4.5	.3
1.0	.6	2.3	41	6.0	.5
1.0	.4	1.3	15	1.7	.7
1.0	.5	3.0	47	11.4	1.0
1.1	.4	2.8	22	4.6	.7
1.1	.3	0.6	13	3.4	.7
1.4	.3	1.3	9	.6	.7
1.4	.5	2.2	23	2.7	.7
1.8	.5	1.3	11	.6	.7
1.8	.6	3.3	18	3.0	.7
2.0	.4	4.8	29	7.0	.7
2.0	.4	1.8	21	5.3	.8
2.0	.5	2.2	31	5.3	.5
2.1	.4	1.9	44	5.1	1.0
2.2	.7	2.5	41	10.5	.3
2.7	.6	1.7	31	9.2	1.7
3.1	.8	2.9	44	17.8	1.0
Average:					
1.5	.5	2.3	26	5.4	.7

Ht. Class (Inches)	No. Trees	Average			
		Feet		Feet	Feet
1.0	10	2.1	22	3.9	.6
2.0	7	2.5	28	5.2	.7
3.0	2	2.3	37	13.3	1.3

Table 2. - Measurements of roots of longleaf pine seedlings

Density: 24 seedlings per milacre. Age: 13 years

Ht. of seedlings	Diameter of seedlings	Length of tap root	No. lateral roots	Total length lateral roots	Depth of most roots
Inches		Feet		Feet	
3.0	.8	2.2	59	11.2	.3
1.5	.4	2.2	33	3.8	1.3
1.5	.5	1.5	27	3.8	.8
2.0	.6	2.0	40	6.3	.8
4.0	.7	4.9	55	9.0	2.0
1.7	.6	2.7	22	9.6	1.0
4.0	.6	5.2	36	9.5	.5
1.7	.6	2.1	22	8.9	1.5
2.0	.5	3.7	19	8.8	.3
2.0	.6	2.7	40	9.2	.7
2.0	.6	2.5	31	9.7	1.0
1.6	.7	2.5	36	7.3	.5
2.0	.4	1.9	22	3.8	1.0
1.0	.4	2.3	12	0.8	0.3
1.5	.5	3.3	16	6.3	0.3
1.8	.6	2.3	33	10.6	2.0
1.8	.6	5.5	41	11.2	0.6
2.0	.5	3.5	25	5.6	2.0
1.9	.6	1.3	28	5.0	0.7
1.2	.5	2.8	22	4.5	1.0
1.7	.6	2.3	34	8.3	1.6
Averages:					
2.0	.6	2.8	31	7.3	1.0

Ht. Class (Inches)	No. Trees	Average			
		Feet		Feet	Feet
1.0	5	2.4	22	3.8	.7
2.0	13	2.7	30	8.0	1.5
3.0	1	2.2	59	11.2	.3
4.0	2	5.0	45	9.3	1.3

Another interesting fact is that the rate of growth of the tap roots is inversely proportional to the rate of growth of the stem. When the growth of the stem is nearly at a standstill the tap root continues to grow rapidly and when height growth of the stem commences the rate of this growth exceeds that of the tap root. When the root reaches a certain depth the physical condition of the soil becomes unfavorable for further rapid growth, due, perhaps, to poor aeration. During this period the rate of growth of the stem exceeds that of the tap root. Wheather or not the energy exerted in the early rapid growth of the tap root is responsible for the very slow growth of the stem during the several years following germination is as yet not known. It may be, however, that when the tap root reaches a certain size, height growth of the stem may commence and the growth may simultaneously continue in the stem and the root until the latter reaches the substratum where conditions for growth become unfavorable, when the vertical growth of the tap root ceases while that of the stem continues. Observations indicate that the rapid development of the longleaf tap root may be the cause of the slow growth of the stem during the several years following germination.

Another point of interest was the notable absence of mycorrhizas on the roots of the seedlings excavated in this study. Very few mycorrhizas were found on the roots of the seedlings either during the winter or during the summer months. Under nursery conditions and in deep sandy soils such as are found in West Florida, mycorrhizas are very abundant on the roots of longleaf pine seedlings. Apparently the physical condition of the soil must be a factor in the distribution of the mycorrhizas.

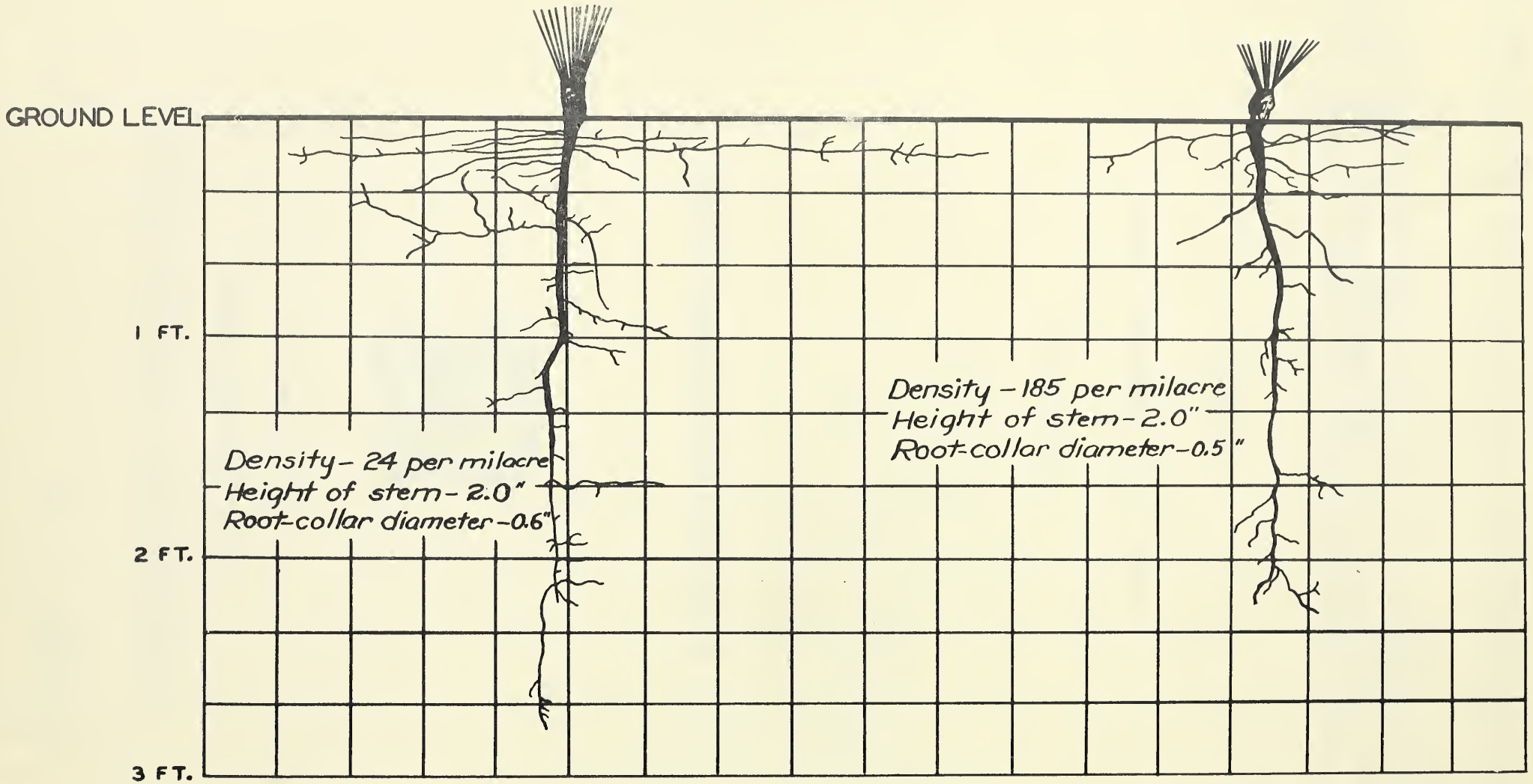
SUMMARY

1. - Roots of seedlings of longleaf pine in their 13th growing season were excavated in two milacres in which the densities were 185 and 24 seedlings per milacre. Both of these quadrats were located on similar sites.

2. - The average height of the stems in the milacre with the higher density was 1.5 inches while the tap root averaged 27.6 inches. In the milacre with the lower density, the height of the seedlings averaged 2.0 inches and the tap root 33.6 inches. The average number of lateral roots in the first milacre was 26 and in the second 31. The total length of the lateral roots was 64.8 inches in the first milacre and 87.6 inches in the second milacre. These data seem to indicate that the density of stocking not only influences the size of the stem but also the size of the root system.

3. - It is evident from the measurements of the excavated seedlings that during the few years following germination, the rate of growth of the tap root is very rapid, far exceeding the rate of the growth of the stem. After height growth commences, the rate of the growth of the tap root slows down. This retarding effect may be due to the roots reaching unfavorable soil conditions.

4. - Under natural conditions on the Ruston fine sandy loam, the roots of the seedlings in both milacres (densities of 185 and 24 per milacre) had no mycorrhizas. The roots of seedlings of the same species of pine when growing on Norfolk sand under natural conditions have been found to be covered with mycorrhizas. Under nursey conditions, likewise, the roots of longleaf seedlings possess mycorrhizas.



ROOTS OF LONGLEAF PINE SEEDLINGS, 13 YEARS OLD
GROWN UNDER SAME SITE CONDITIONS